Table C-1. Stressors, Stressor Effects, and Impact Mechanisms for Delta Smelt

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced food	Starvation, higher susceptibility to disease, reduced reproduction	Non-native species (e.g., *Corbula*) reduce food available to delta smelt by eating/filtering out organics, phytoplankton, and zooplankton.	Can affect larvae, juveniles, and adults in all locations throughout the year, but mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods **Certainty:** 3		Kimmerer & Orsi 1996, Sweetnam 1999, Jassby et al. 2002, Kimmerer 2002a
		Upstream reservoir operations dampen high flows and reduce the frequency and duration of seasonal floodplain inundation and mobilization and downstream transport of nutrients and organic matter	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, mainly in drier years, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high **Certainty:** 3	Increased input of nutrients and organic matter may not benefit smelt if it is removed by SWP, CVP, or in-Delta diversions or competitors, or if hydrologic residence time is too low to utilize it	Jassby et al. 2002, Pelagic Fish Action Plan 2007
		Nutrients and phytoplankton and zooplankton production are exported by SWP, CVP, and in-Delta diversions with water	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high **Certainty:** 3		Jassby et al. 2002, Pelagic Fish Action Plan 2007

Table C-1. Stressors, Stressor Effects, and Impact Mechanisms for Delta Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Hydrologic residence time in the Delta, which affects phytoplankton and zooplankton production, is reduced by the need to maintain a hydrologic barrier to keep exported water fresh and the use of Delta channels for water conveyance to the SWP and CVP export facilities	Can affect larvae, juveniles, and adults throughout the year, mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods **Certainty:** 3		Jassby et al. 2002, Kimmerer 2002a,b, Pelagic Fish Action Plan 2007
		Mortality of prey species that are exposed to toxics can occur, reducing food abundance to delta smelt	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, rearing juveniles and adults in western Delta and Suisun Bay **Certainty:** 1		Weston et al. 2004, Luoma 2007
Reduced rearing habitat	Reduced growth, increased competition	Water operations have compressed the estuarine salinity field.	Moderately widespread, influences rearing juveniles and adults and spawning in adults, episodic, mainly in Fall when outflow is low **Certainty:** 4		Swanson et al. 2000, Monismith et al. 2002, Kimmerer 2002a,b, Bennett 2005, Sommer 2006, Feyrer et al. 2007, Pelagic Fish Action Plan 2007
Reduced turbidity	Reduced foraging efficiency	Reduction in hydrologic residence time decreases organic material in the Delta	Widespread stressor throughout geographic range, influences rearing juveniles and adults, episodic, mainly in Fall **Certainty:** 3		Basker-Bridges et al. 2004, Feyrer et al. 2007, Pelagic Fish Action Plan 2007

Table C-1. Stressors, Stressor Effects, and Impact Mechanisms for Delta Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Corbula reduces organic material in the water column	Specific to west Delta and Suisun Bay, influences rearing juveniles and adults. Varies temporally in influence on the species **Certainty:** 4		Kimmerer & Orsi 1996, Sweetnam 1999, Jassby et al. 2002, Kimmerer 2002a
		Egeria and other non-native invasive aquatic plants trap and remove suspended sediments from the water column	Widespread, varies seasonally, influences juveniles and adults **Certainty:** 3		Nestor et al. 2003
		Upstream water management & channelization reduces sediment input	Widespread, varies seasonally, mostly in non-rainy periods, influences juveniles and adults **Certainty:** 3		Jassby et al. 2002
Reduced spawning habitat	Reduction in reproductive success	Reclaiming wetlands and islands reduced shallow freshwater habitat, which is thought to be spawning habitat	Widespread throughout geographic range, affects adults during spawning season (late winter/early spring) **Certainty:** 3		Bennett 2005
Reduced food quality	Increased time needed to forage, starvation, reduced reproduction	Introductions of non-native zooplankton species have displaced native forage species that are less efficient to consume (due to size, protection, and speed) (e.g., *Limnoithona*)	Moderately widespread throughout geographic range, episodic, affects larvae, juveniles and adults **Certainty:** 3		Pelagic Fish Action Plan 2007

Table C-1. Stressors, Stressor Effects, and Impact Mechanisms for Delta Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Unnatural mortality	Mortality	Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on delta smelt	Widespread throughout geographic range, impacts larvae, juveniles, adults, year-round **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006
		Reduced turbidity allows visual predators to forage more efficiently on delta smelt	Widespread stressor throughout geographic range, influences all stages, episodic, mainly in Fall **Certainty:** 3		Feyrer et al 2007; Pelagic Fish Action Plan 2007
CVP/SWP entrainment [1]	Mortality, injury, displacement if salvaged successfully	Reverse flows in Old and Middle rivers entrain delta smelt, eventually moving them into the SWP and CVP export facilities	Limited range, adults affected during spawning season (December-March), larvae and juveniles affected during first few months of life (usually Feb-June) **Certainty:** 2	When salinity is high, fish move farther upstream, increasing probability of entrainment into O&M rivers	Bennett 2005, Pelagic Fish Action Plan 2007, Sommer et al. 2007
Exposure to toxics	Sublethal and lethal effects, increased susceptibility to disease	Toxics enter the system from a variety of point and non-point sources including agricultural and urban run-off	Widespread throughout geographic range, can be episodic and chronic, can affect all life stages **Certainty:** 1		Sommer 2006, Bennett unpubl. data, Werner 2006, 2007, Herbold pers. comm., Pelagic Fish Action Plan 2007

[1]Although it is recognized that the risk of entrainment at the SWP and CVP export facilities may, in some years, be a high level stressor to delta smelt, and in some years represents a very low level stressor to delta smelt, for purposes of the analysis the risk of delta smelt entrainment under each of the Options has been characterized, on average, as a moderate level stressor to the population.

Other stressors:

- Propeller entrainment by cargo vessels
- Monitoring mortality
- Reduced dissolved oxygen
- Fish stranding
- Passage barriers
- Reduced habitat diversity
- Entrainment at:
  - Private unscreened diversions
  - DWR owned diversions
  - Rock Slough
  - Mirant Pittsburg and Contra Costa power plants
  - North Bay Aqueduct

Individuals participating in the BDCP technical working sessions for Delta smelt:

Bill Bennett (UC Davis) Chuck Hanson (Hanson Environmental); Diane Windham, Bruce Oppenheim, and Rosalie del Rosario (NMFS); Jim White, Randy Baxter, Alice Low, Kevin Flemming, and Neil Clipperton (DFG); Bill Harrell (DWR); Bill Bennett (UC Davis); Rick Sitts, David Fullerton, and Pete Rhoads (Metropolitan); Ron Kino (Mirant); Campbell Ingram (TNC); and Pete Rawlings and Rick Wilder (SAIC)

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Table C-2. Stressors, Stressor Effects, and Impact Mechanisms for Longfin Smelt

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced access to spawning habitat	Increased energy use, sub-optimal spawning habitat, mortality	Low winter/spring outflows move low salinity zone upstream, forcing spawners to move farther upstream to reach spawning habitat	Widespread throughout geographic range, during winter & spring, affects adults. **Certainty** = 3	Movement upstream causes increased probability of entrainment at pumps	Kimmerer 2002a,b; Sommer et al. 2007
Reduced access to rearing habitat	Sub-optimal growth, mortality	Low winter/spring outflow does not transport larvae, acting as passive particles, downstream	Widespread throughout geographic range, during winter & spring, affects larvae. **Certainty** = 3	Increased time upstream increases probability of entrainment at pumps, food supplies for larvae are reduced within the river	Kimmerer 2002a; Sommer et al. 2007
Reduced food	Starvation, reduced reproduction, higher susceptibility to disease	Non-native species (e.g., *Corbula*) reduce food available to longfin smelt by eating/filtering out organics, phytoplankton, and zooplankton.	Can affect larvae, juveniles, and adults in all locations throughout the year, but mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods. **Certainty** = 4		Kimmerer & Orsi 1996, Sweetnam 1999, Jassby et al. 2002, Kimmerer 2002a, 2004
		Upstream reservoir operations dampen high flows and reduce the frequency and duration of seasonal floodplain inundation and mobilization and downstream transport of nutrients and organic matter	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, mainly in drier years, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high. **Certainty** = 3		Jassby et al. 2002, Pelagic Fish Action Plan 2007

Table C-2. Stressors, Stressor Effects, and Impact Mechanisms for Longfin Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Upstream nutrients and production are exported by SWP, CVP, and in-Delta diversions with water	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high. **Certainty** = 3		Jassby et al. 2002, Pelagic Fish Action Plan 2007
		Hydrologic residence time, which affects phytoplankton and zooplanktonproduction, is reduced by the need to maintain a hydrologic barrier to keep exported water fresh and the use of Delta channels for water conveyance. .	Can affect larvae, juveniles, and adults throughout the year, mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods. **Certainty** = 3		Jassby et al. 2002, Kimmerer 2002a,b, 2004, Pelagic Fish Action Plan 2007
		Mortality of prey species that are exposed to toxics can occur, reducing food abundance to longfin smelt	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, rearing juveniles and adults in western Delta and Suisun Bay **Certainty:** 1		Weston et al. 2004, Luoma 2007
Unnatural predation	Mortality	Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on longfin smelt	Widespread throughout geographic range, impacts larvae, juveniles, adults, year-round. **Certainty** = 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006

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Table C-2. Stressors, Stressor Effects, and Impact Mechanisms for Longfin Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
Reduced turbidity	Reduced foraging efficiency, increased vulnerability to predation	Reduction in hydrologic residence time decreases organic material in the Delta, changes in hydrology and scour (riprapped levees) has reduced sediment inputs	Widespread stressor throughout geographic range, influences rearing juveniles and adults, episodic, mainly in Fall. **Certainty** = 3		Pelagic Fish Action Plan 2007, S. Foote unpubl. data,
		Corbula reduces organic material in the water column	Specific to west Delta and Suisun Bay, influences rearing juveniles and adults. Varies temporally in influence on the species. **Certainty** = 4		Kimmerer & Orsi 1996, Jassby et al. 2002, Kimmerer 2002a, 2004
		Egeria and other non-native invasive aquatic plants trap and remove suspended sediments from the water column	Widespread, varies seasonally, influences juveniles and adults. **Certainty** = 3		Nestor et al. 2003
		Upstream water management & channelization reduces sediment input	Widespread, varies seasonally, mostly in non-rainy periods, influences juveniles and adults. **Certainty** = 3		Jassby et al. 2002
Reduced spawning habitat	Reduction in reproductive success	Reclaiming wetlands and islands reduced shallow freshwater habitat, which is thought to be spawning habitat	Widespread throughout spawning range, affects adults during spawning season (late winter/early spring). **Certainty** = 2		Pelagic Fish Action Plan 2007
		Channelization and rip-rapping of channels reduces the amount of shallow water habitat suitable for spawning	Widespread throughout spawning range affects adults during spawning season (late winter/early spring). **Certainty** = 2		Pelagic Fish Action Plan 2007

Table C-2. Stressors, Stressor Effects, and Impact Mechanisms for Longfin Smelt (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
Reduced food quality	Increased time needed to forage, starvation, reduced reproduction	Introductions of non-zooplankton peciesnatives have displaced native forage species that are less efficient to consume (due to size, protection, and speed) (e.g., *Limnoithona*)	Moderately widespread throughout geographic range, episodic, affects juveniles and adults. **Certainty** = 2		Pelagic Fish Action Plan 2007
Moderately Important Stressors					
CVP/SWP entrainment[1]	Mortality, injury, displacement if salvaged successfully	Reverse flows in Old and Middle rivers (high E:I ratio) entrain longfin smelt, eventually moving them into the SWP and CVP export facilities	Adults affected during spawning season (December-March), larvae and juveniles affected during first few months of life (~Feb-May). **Certainty** = 2	Depends on location of fish, which is influenced by low salinity zone and outflow	T. Swanson unpubl. data, POD Action Plan 2007
Reduced rearing habitat	Reduced growth, increased competition	Water operations have compressed the estuarine salinity field through reductions in seasonal Delta outflow.	Moderately widespread, influences rearing juveniles and adults and spawning in adults, episodic, mainly in Fall when outflow is low. **Certainty** = 3		Kimmerer 2002a,b, Bennett 2005, Sommer 2006, Pelagic Fish Action Plan 2007
Exposure to toxics	Sublethal and lethal effects, increased susceptibility to disease	Toxics enter the system from a variety of point and non-point sources including agricultural and urban run-off	Widespread throughout geographic range, can be episodic and chronic, can affect all life stages. **Certainty** = 1		S. Foote unpubl. data, Pelagic Fish Action Plan 2007

[1]Although it is recognized that the risk of entrainment at the SWP and CVP export facilities may, in some years, be a high level stressor to longfin smelt, and in some years represents a very low level stressor to longfin smelt, for purposes of the analysis the risk of longfin smelt entrainment under each of the Options has been characterized, on average, as a moderate level stressor to the population.

Other stressors:

- Monitoring mortality
- Propeller entrainment by cargo vessels
- Fish stranding
- Passage barriers
- Other entrainment
  - Private unscreened diversions
  - DWR owned diversions
  - USBR owned diversion (Rock Slough)
  - Mirant Pittsburg/Contra Costa power plants
  - North Bay Aqueduct

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Table C-3. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Chinook Salmon (winter-run, spring-run, and fall-/late fall-run)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced staging and spawning habitat	Reduced spawning success, competition for remaining habitat, increased probability of inter-racial breeding, redd superimposition and reduced reproductive success	Man-made structures (e.g., dams, weirs) prohibit access to upstream staging and spawning habitat	Primarily upstream of Delta, during staging and spawning season, in all years, influences spawning adults migrating upstream **Certainty:** 4		USBR 2004, DWR 2005
		Blockage of gravel recruitment from upstream areas by reservoirs, removal of gravel by humans or increased sedimentation has reduced gravel availability needed for spawning	Upstream of the Delta, during staging and spawning season, primarily in low flow years, spawning adults migrating upstream **Certainty:** 3		Yoshiyama et al. 1998
		Low flows from upstream dams do not provide attraction cues needed by spawning adults to gain access to natal spawning grounds, reduced migration cues	Primarily upstream of the Delta, during staging and spawning season, primarily in low flow years, spawning adults migrating upstream **Certainty:** 3		Yoshiyama et al. 1998
Reduced rearing and outmigration habitat	Reduced juvenile growth/survival	Reclaiming wetlands and islands has reduced shallow, low velocity habitat	Throughout the Delta, year-round, all years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Yoshiyama et al. 1998, Williams 2006
		Man-made structures (e.g., dams, weirs) prohibit access to rearing habitat, increase vulnerability to predation	Primarily upstream of the Delta, year-round, affects rearing juveniles **Certainty:** 4		USBR 2004, DWR 2005, NOAA 2005

Table C-3. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Chinook Salmon (winter-run, spring-run, and fall-/late fall-run) (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Upstream reservoir operations and reclamation (levee construction) has reduced the frequency and duration of seasonal floodplain inundation, mobilization and downstream transport of nutrients and organic carbon, and other flow-dependent habitat (salmon rearing habitat and outmigration pathway)	Specific to floodplains, during winter/spring with high flows, some years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Sommer et al. 2001, 2004, Moyle et al. 2007
		Riprapped levees reduce shallow water, low velocity habitat and overbank flow	Throughout the Delta, year-round, all years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Yoshiyama et al. 1998
Predation by non-native species	Mortality	Reduction in spatial complexity (habitat diversity) of channels reduces refuge space from predators, use of riprapped stabilized channel levees reduces cover habitat and increases vulnerability to predation	Widespread throughout aquatic range, impacts rearing and outmigrating fry and juveniles primarily, year-round **Certainty:** 3		Missildine et al. 2001, Sommer et al. 2001, 2004
		Instream gravel pits and flooded ponds attract non-native warm water predators and lack cover for salmon	Primarily upstream of the Delta, impacts juveniles rearing and migrating downstream **Certainty:** 2		Demko 1998, DWR 2005

Table C-3. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Chinook Salmon (winter-run, spring-run, and fall-/late fall-run) (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on salmon	Widespread throughout aquatic range, impacts outmigrating fry and juveniles year-round **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006
Moderately Important Stressors					
Harvest	Mortality	Legal and illegal	Occurs primarily in ocean, but some harvest of spawning adults migrating upstream throughout migration pathways during spawning season, moderately high certainty for legal, moderate certainty for illegal **Certainty**: 3		Yoshiyama 1998, USBR 2004, Williams 2006
Reduced genetic diversity/ integrity	Increased risk of extinction	Hatcheries reduce genetic diversity	Throughout range, year-round, all life stages **Certainty:** 2	Hatchery practices may also increase vulnerability to disease	USFWS 2001, Williams 2006
CVP/SWP entrainment	Mortality, injury, displacement if salvaged successfully	Reverse flows in Old and Middle rivers entrain salmon, eventually moving them into the SWP and CVP export facilities	Limited range, primarily Feb-June, fry and juveniles **Certainty:** 3		USFWS 1987, Brandes & McLain 2001, USBR 2004
Exposure to toxics	Lethal and sub-lethal effects, increased susceptibility to predation	Point and non-point sources	Throughout the Delta, year-round, all years, all life stages while in the Delta **Certainty:** 1		Klabrat et al. 1992, Moyle 2002, USBR 2004

Table C-3. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Chinook Salmon (winter-run, spring-run, and fall-/late fall-run) (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Increased water temperature	Physiological stress, reduced spawning success, mortality	Low flows from dam releases, reduced cold water pool storage in upstream reservoirs, reduced riparian vegetation and shading	Widespread throughout the Delta and tributary rivers during spring/summer/fall, occurs primarily in drier years, affects all life stages **Certainty:** 3	Low flows also increase hydrologic residence time, increase juvenile migration time, contribute to localized depressions in DO	USFWS 1999, Myrick & Cech 2001, USBR 2004

Other stressors:

- Increased fine sediments
- Monitoring mortality
- Propeller entrainment by cargo vessels
- Reduced food
- Salinity control/compliance
- Competition with hatchery-reared individuals

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Table C-4. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Chinook Salmon (fall-run)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced staging and spawning habitat	Reduced spawning success, competition for remaining habitat, redd superimposition and reduced reproductive success	Man-made structures (e.g., dams, weirs) prohibit access to upstream staging and spawning habitat	Primarily upstream of Delta, during staging and spawning season (fall/winter), in all years, influences spawning adults migrating upstream **Certainty:** 4		USBR 2004, DWR 2005
		Low flows from upstream dams do not provide attraction cues needed by spawning adults to gain access to natal spawning grounds, reduced migration cues	Primarily upstream of the Delta, during staging and spawning season (fall/winter), primarily in low flow years, spawning adults migrating upstream **Certainty:** 3		Yoshiyama et al. 1998
		Blockage of gravel recruitment from upstream areas by reservoirs, removal of gravel by humans or increased sedimentation has reduced gravel availability needed for spawning	Primarily upstream of the Delta, during staging and spawning season, primarily in low flow years, spawning adults migrating upstream **Certainty:** 3		Yoshiyama et al. 1998
Reduced rearing and outmigration habitat	Reduced juvenile growth/survival	Upstream reservoir operations and reclamation (levee construction) has reduced the frequency and duration of seasonal floodplain inundation , mobilization and downstream transport of nutrients and organic carbon, and other flow-dependent habitat (salmon rearing habitat and outmigration pathway)	Specific to floodplains, during winter/spring with high flows, some years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Sommer et al. 2001, 2004, Moyle et al. 2007

1 Table C-4. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Chinook Salmon (fall-run) (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Man-made structures (e.g., dams, weirs, boat locks) prohibit access to rearing habitat	Primarily upstream of the Delta, Jan-Jun, affects rearing juveniles **Certainty:** 4		USBR 2004, DWR 2005, NOAA 2005
		Reclaiming wetlands and islands reduced shallow, low velocity habitat, increase vulnerability to predation	Throughout the Delta, Jan-Jun, all years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Yoshiyama et al. 1998, Williams 2006
		Low flows due to low inflows or high export rates increase water temperature and residence time, resulting in dissolved oxygen levels	Specific areas of low flow in Delta (e.g., Stockton Shipping Channel), late summer-late fall, affects rearing and outmigrating fry and juveniles and upstream adult migration **Certainty:** 4	Can also cause localized fish kills	USBR 2004, DWR 2006
		Riprapped levees reduce shallow water, low velocity habitat and overbank flow	Throughout the Delta, Jan-Jun, all years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		Yoshiyama et al. 1998
Exposure to toxics	Lethal and sub-lethal effects, increased susceptibility to predation	Point and non-point sources	Throughout the Delta, year-round, all years, all life stages while in the Delta **Certainty:** 2		Saiki et al. 1992, Klaprat et al. 1992, Moyle 2002, USBR 2004
Predation by non-native species	Mortality	Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on salmon	Widespread throughout geographic range, primarily Jan-Jun, impacts outmigrating fry and juveniles **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006

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1 **Table C-4. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Chinook Salmon (fall-run)** (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Instream gravel pits and flooded ponds attract non-native warm water predators and lack cover for salmon	Primarily upstream of the Delta, Jan-Jun, impacts juveniles rearing and migrating downstream **Certainty:** 2		Demko 1998, DWR 2005
		Reduction in spatial complexity (habitat diversity) of channels reduces refuge space from predators, use of riprapped stabilized channel levees reduces cover habitat and increases vulnerability to predation	Widespread throughout aquatic range, impacts rearing and outmigrating fry and juveniles primarily, Jan-Jun **Certainty:** 3		Missildine et al. 2001, Sommer et al. 2001, 2004
Moderately Important Stressors					
Reduced genetic diversity/ integrity	Susceptibility to disease	Hatcheries reduce genetic diversity	Throughout range, year-round, all life stages, low certainty	Hatchery practices may also increase vulnerability to disease	USFWS 2001, Williams 2006
Harvest	Mortality	Legal and illegal	Occurs primarily in ocean, but some harvest of spawning adults migrating upstream throughout migration pathways during spawning season **Certainty:** 3		Yoshiyama 1998, USBR 2004, Williams 2006
CVP/SWP entrainment	Mortality, injury, displacement if salvaged successfully	Reverse flows in Old and Middle rivers entrain salmon, eventually moving them into the SWP and CVP export facilities	Limited range, primarily Jan-Jun, fry and juveniles **Certainty:** 3		USFWS 1987, Brandes & McLain 2001, USBR 2004

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Table C-4. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Chinook Salmon (fall-run) (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Increased water temperature	Physiological stress, reduced spawning success, mortality	Low flows from dam releases, reduced cold water pool storage in upstream reservoirs, reduced riparian vegetation and shading	Widespread throughout the Delta and tributary rivers during spring/summer/fall, occurs primarily in drier years, affects all life stages **Certainty:** 3	Low flows also increase hydrologic residence time, increase juvenile migration time, contribute to localized depressions in DO	USFWS 1999, Myrick & Cech 2001, USBR 2004

Other stressors:

- Increase in fine sediment
- Monitoring mortality
- Propeller entrainment by cargo vessels
- Reduced food
- Salinity control/compliance
- Competition with hatchery-reared individuals
- Other entrainment

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Table C-5. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Central Valley Steelhead

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced staging and spawning habitat	Reduced spawning success, competition for remaining habitat, redd superimposition and reduced reproductive success	Man-made structures (e.g., dams, weirs) prohibit access to upstream staging and spawning habitat	Primarily upstream of Delta, September-April, in all years, influences adults migrating upstream **Certainty:** 4		USBR 2004, DWR 2005, NOAA 2005, Lindley et al. 2006
		Low flows from upstream dams do not provide attraction cues needed by spawning adults to gain access to natal spawning grounds, reduced migration cues	Primarily upstream of the Delta, September-April, primarily in low flow years **Certainty:** 3		DWR 2005
		Blockage of gravel recruitment from upstream areas by reservoirs, removal of gravel by humans or increased sedimentation has reduced gravel availability needed for spawning	Upstream of the Delta, September-April, reduces spawning habitat and egg incubation/hatching success **Certainty:** 3		Mesick 1998
Entrainment	Mortality, injury, displacement if salvaged successfully at the SWP and CVP export facilities	Reverse flows in Old and Middle rivers entrain or guide steelhead, increasing their vulnerability to entrainment and salvage at the CVP/SWP export facilities	Limited range, primarily Feb-June, fry and juveniles **Certainty:** 3		USBR 2004, Williams 2006
		Other screened and unscreened diversions	Widespread, primarily Feb-June, fry and juveniles **Certainty:** 2		Herren & Kawasaki 2004, USBR 2004

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Table C-5. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Central Valley Steelhead (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
Reduced rearing and outmigration habitat	Reduced juvenile growth/survival	Upstream reservoir operations dampen high flows, reducing extent and duration of inundation of floodplains, mobilization and downstream transport of nutrients and organic material, and other flow-dependent habitat (steelhead rearing habitat and outmigration pathway)	Specific to floodplains, during winter/spring with high flows, some years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		NOAA 2005, DWR 2005
		Man-made structures (e.g., dams, weirs) prohibit access to upstream juvenile rearing habitat, increase vulnerability to predation	Primarily upstream of the Delta, year-round, affect rearing juveniles **Certainty:** 3		DFG 1996, USBR 2004, DWR 2005, NOAA 2005
		Reclaiming wetlands and islands has reduced shallow, low velocity habitat	Throughout the Delta, year-round, all years, influences rearing juveniles **Certainty:** 4		Williams 2006
		Riprapped levees reduce shallow water, low velocity habitat and overbank flow	Throughout the Delta and upstream reaches of the Sacramento River and many tributaries, year-round, all years, influences rearing juveniles **Certainty:** 4		DFG 1996, DWR 2005

Table C-5. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Central Valley Steelhead (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
Predation by non-native species	Mortality	Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on juvenile steelhead	Widespread throughout geographic range, impacts outmigrating and rearing juveniles year-round **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006
		Instream gravel pits and flooded ponds attract non-native warm water predators and lack cover for juvenile steelhead	Primarily upstream of the Delta, impacts juveniles rearing and migrating downstream **Certainty:** 2		DWR 2005, NOAA 2005
		Reduction in spatial complexity (habitat diversity) of channels reduces refuge space from predators	Widespread throughout aquatic range, impacts rearing and outmigrating fry and juveniles primarily, year-round **Certainty:** 3		Raleigh et al. 1984, Missildine et al. 2001, NOAA 2005
Moderately Important Stressors					
Exposure to toxics	Lethal and sub-lethal effects, reduced health, growth, survival, and reproductive success	Point and non-point sources	Throughout the Delta, year-round, all years, all life stages while in the Delta **Certainty:** 3		DFG 1996, USBR 2004, Klinck et al. 2005
Reduced genetic diversity/ integrity	Increased risk of extinction	Hatcheries reduce genetic diversity	Throughout range, year-round, all life stages **Certainty:** 2	Hatchery practices may also increase vulnerability to disease	USFWS 2001, Williams 2006
Harvest	Mortality	Legal and illegal	Harvest of adults migrating upstream throughout migration pathways, primarily Sept-Mar, greatest in upstream river reaches **Certainty:** 3		USBR 2004, DWR 2005, Williams 2006

Table C-5. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento River Central Valley Steelhead (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Increased water temperature	Physiological stress, reduced spawning success, increased mortality	Low flows from dam releases, reduced cold water pool storage in upstream reservoirs, reduced riparian vegetation and shading	Widespread throughout the Delta and tributary rivers, during spring/summer/fall, occurs primarily in drier years, affects all life stages, primarily rearing juveniles **Certainty:** 3	Low flows also increase hydrologic residence time, increase juvenile migration time, and contribute to increased vulnerability to predation mortality	McEwan & Jackson 1996, IEP Steelhead PWT 1998, USBR 2004, Myrick & Cech 2004

Other stressors:

- Increase in fine sediment
- Propeller entrainment by cargo vessels
- Monitoring mortality
- Salinity control/compliance
- Cold water management
- Reduced food
- Competition with hatchery-reared individuals

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Table C-6. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Central Valley Steelhead

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced staging and spawning habitat	Reduced spawning success, competition for remaining habitat, redd superimposition and reduced reproductive success	Man-made structures (e.g., dams, weirs) prohibit access to upstream staging and spawning habitat	Primarily upstream of Delta, September-April, in all years, influences adults migrating upstream **Certainty:** 4		DFG 1996, USBR 2004, DWR 2005, NOAA 2005, Lindley et al. 2006
		Low flows from upstream dams or increased export rates do not provide attraction cues needed by spawning adults to gain access to natal spawning grounds, reduced adult and juvenile migration cues	Primarily upstream of the Delta, September-April, primarily in low flow years, adults migrating upstream **Certainty:** 3		DWR 2005
		Blockage of gravel recruitment from upstream areas by reservoirs, removal of gravel by humans or increased sedimentation has reduced gravel availability needed for spawning	Upstream of the Delta, September-April, reduces spawning habitat and egg incubation/hatching success **Certainty:** 3		Mesick 1998
Reduced rearing and outmigration habitat	Reduced growth/survival	Upstream reservoir operations or water exports dampen high flows, reducing extent and duration of inundation of floodplains and other flow-dependent habitat (steelhead rearing habitat and outmigration pathway)	Specific to floodplains, during winter/spring with high flows, some years, influences rearing and outmigrating fry and juveniles **Certainty:** 4		NOAA 2005, DWR 2005
		Man-made structures (e.g., dams, weirs, boat locks) prohibit access to rearing habitat	Primarily upstream of the Delta, year-round, affects rearing juveniles **Certainty:** 4		DFG 1996, USBR 2004, DWR 2005, NOAA 2005

1 **Table C-6. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Central Valley Steelhead (continued)**

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Reclaiming wetlands and islands has reduced shallow, low velocity habitat	Throughout the Delta, year-round, all years, influences rearing juveniles **Certainty:** 4		Williams 2006
		Riprapped levees reduce shallow water, low velocity habitat and overbank flow	Throughout the Delta, year-round, all years, influences rearing juveniles **Certainty:** 4		DFG 1996, DWR 2005
		Low flows due to low inflows or high export rates increase water temperature and residence time, resulting in dissolved oxygen levels	Specific areas of low flow in Delta (e.g., Stockton Shipping Channel), affects rearing and outmigrating juveniles, during late summer-fall **Certainty:** 4	Can also cause localized fish kills	USBR 2004, DWR 2006
Exposure to toxics	Lethal and sub-lethal effects, increased susceptibility to predation	Point and non-point sources	Throughout the Delta, year-round, all years, all life stages while in the Delta **Certainty:** 3		DFG 1996, USBR 2004, Klinck et al. 2005
Reduced genetic diversity/ integrity	Susceptibility to disease, increased risk of extinction	Hatcheries reduce genetic diversity	Throughout range, year-round, all life stages **Certainty:** 2		USFWS 2001, Williams 2006
Predation by non-native species	Mortality	Reduction in spatial complexity (habitat diversity) of channels reduces refuge space from predators	Widespread throughout aquatic range, impacts rearing and outmigrating fry and juveniles primarily, year-round **Certainty:** 3		Raleigh et al. 1984, Missildine et al. 2001, DWR 2005, NOAA 2005

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Table C-6. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Central Valley Steelhead (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on salmon	Widespread throughout geographic range, impacts outmigrating and rearing juveniles year-round **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006
		Instream gravel pits and flooded ponds attract non-native warm water predators and lack cover for salmon	Primarily upstream of the Delta, impacts juveniles rearing and migrating downstream **Certainty:** 2		DWR 2005, NOAA 2005
Moderately Important Stressors					
CVP/SWP entrainment	Mortality, injury, displacement if salvaged successfully at the SWP and CVP export facilities	Reverse flows in Old and Middle rivers entrain or guide steelhead, increasing their vulnerability to entrainment and salvage at the CVP/SWP export facilities	Limited range, primarily Feb-June, fry and juveniles **Certainty:** 3		DWR & USBR 1999, USBR 2004
Harvest	Mortality	Legal and illegal	Harvest of adults migrating upstream throughout migration pathways, primarily Sept-Mar, greatest in upstream river reaches **Certainty:** 3		Mesick 1998, USBR 2004, DWR 2005, Williams 2006

Table C-6. Stressors, Stressor Effects, and Impact Mechanisms for San Joaquin River Central Valley Steelhead (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Increased water temperature	Physiological stress, reduced spawning success, increased mortality	Low flows from dam releases, reduced cold water pool storage in upstream reservoirs, reduced riparian vegetation and shading	Widespread throughout the Delta and tributary rivers, during spring/summer/fall, occurs primarily in drier years, affects all life stages, primarily rearing juveniles **Certainty:** 3	Low flows also increase hydrologic residence time, increase juvenile migration time, and contribute to increased vulnerability to predation mortality	McEwan & Jackson 1996, IEP Steelhead PWT 1998, Myrick & Cech 2004, USBR 2004

Other stressors:

- Increase in fine sediment
- Propeller entrainment by cargo vessels
- Other entrainment
- Monitoring mortality
- Salinity control/compliance
- Cold water management
- Reduced food
- Competition with hatchery-reared individuals

Individuals participating in the BDCP technical working sessions for covered salmonids:

Chuck Hanson (Hanson Environmental); Diane Windham, Bruce Oppenheim, and Rosalie del Rosario (NMFS); Jim White, Randy Baxter, Alice Low, and Neil Clipperton (DFG); Bill Harrell (DWR); Bill Bennett (UC Davis); Rick Sitts, David Fullerton, and Pete Rhoads (Metropolitan); Ron Kino (Mirant); Campbell Ingram (TNC); and Pete Rawlings and Rick Wilder (SAIC).

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Table C-7. Stressors, Stressor Effects, and Impact Mechanisms for Green Sturgeon

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Very Important Stressors					
Reduced spawning habitat	Reduced reproductive success	Artificial barriers (dams, weirs) prohibit access to upstream spawning habitat	Upstream only, spawning season (late spring-early summer) in all years, influences spawning adults **Certainty:** 3	Also contributes to reductions in upstream juvenile rearing habitat	CDWR 2005, NOAA Fisheries 2005, Heublein et al 2006
Exposure to toxics	Sublethal and lethal effects, increased susceptibility to disease	*Corbula* and *Corbicula* as a food source contribute to bioaccumulation of toxics like selenium in sturgeon tissue via consumption	Specific to locations with *Corbula* and *Corbicula* presence (e.g., western Delta, Suisun Bay), year-round, affects subadults and non-marine adults **Certainty:** 2		EPIC et al 2001, Moyle 2002, Doroshov 2006
		Point and non-point sources	Widespread, year-round, affects all non-marine lifestages **Certainty:** 1		Klimley 2002
Harvest	Mortality	Illegal (for roe) and incidental harvest as part of the white sturgeon recreational fishery	Problem has increased in past few years, mostly in rivers, year-round mostly spawning females, influences sub-adults and adults **Certainty:** 2		CDFG 2002, M. Donnellan pers comm., Lt. L. Schwall pers comm..
Moderately Important Stressors					
Reduced rearing habitat	Reduced growth rates, increased predation	Reclaiming wetlands and islands reduced in- and off-channel rearing habitat	Widespread in Delta, year-round, juveniles and sub-adults **Certainty:** 1		
		Channelized riprap levees reduce in- and off-channel intertidal and shallow subtidal rearing habitat, including seasonal inundation of floodplain habitat	Widespread in Delta and upstream, year-round, juveniles and sub-adults **Certainty:** 1		

1 **Table C-7. Stressors, Stressor Effects, and Impact Mechanisms for Green Sturgeon (continued)**

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors (cont.)					
Increased water temperature	Increased heat-related physiological stress (heat-shock proteins), increased susceptibility to disease, mortality	Reduced flows from upstream reservoirs increase hydrologic resident time, allowing water to warm, reduced riparian vegetation and shading	Occurs in Feather River, primarily in spring/summer, primarily influences eggs and juveniles Certainty: 3		NOAA Fisheries 2005, Van Eenennaam et al. 2005, Allen et al 2006a,b
Unnatural mortality	Mortality	Predation by non-natives	Only been shown for white sturgeon but likely translates to larval and early juvenile green sturgeon, occurs upstream in and near spawning habitat during and shortly after spawning season, affects larvae and juveniles **Certainty:** 3	Predation risk increases with lower turbidity	Gadomski & Parsely 2005a
		Dredging directly entrains sturgeon	Occurs in specific main channels, year-round, rearing juveniles and sub-adults **Certainty**: 2		
Reduced turbidity	Increased risk of predation	Upstream water management & channelization reduces sediment input	Only been shown for white sturgeon but likely translates to green sturgeon, occurs upstream in and near spawning habitat during and shortly after spawning season, affects larvae **Certainty:** 2		Jassby et al 2002, Gadomski & Parsley 2005b

Other Stressors:

- Unnatural mortality
  - Monitoring mortality
  - Stranding
- Entrainment (SWP, CVP, and others)
- Salinity control
- Reduced food

Individuals participating in the BDCP technical working sessions for sturgeon include:

Diane Windham and Jeff Stuart (NMFS); Scott Cantrell, Tom Schroyer, and Mike Donnellan (DFG); Zoltan Matica and Alicia Seesholtz (DWR); Rick Sitts (Metropolitan); Campbell Ingram (TNC); Josh Israel (UC Davis); Chuck Hanson (Hanson Environmental); Pete Rawlings and Rick Wilder (SAIC).

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1 **Table C-8. Stressors, Stressor Effects, and Impact Mechanisms for White Sturgeon**

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Very Important Stressors					
Harvest	Mortality	Legal (recreational fishery)	Moderate spatial range, year-round, affects subadults and adults, angling regulations have been modified to increase protection in recent years **Certainty:** 3		USFWS 1995, M. Donnellan pers. comm.
		Illegal (for roe)	Problem has increased in past few years, mostly in rivers, mostly during spawning season, enforcement efforts have increased in recent years **Certainty:** 2		Lt. L. Schwall pers. comm.
Reduced spawning habitat	Reduced reproductive success	Artificial barriers (dams, weirs) prohibit access to upstream spawning habitat	Upstream only, spawning season (late spring-early summer) in all years, influences spawning adults **Certainty:** 3		Matica pers. comm., J. Israel dissertation
Exposure to toxics	Sublethal and lethal effects, increased susceptibility to disease	*Corbula* and *Corbicula* as a food source contribute to bioaccumulations of toxics like selenium in sturgeon tissue via consumption	Specific to locations with *Corbula* and *Corbicula* presence (e.g., western Delta, Suisun Bay), year-round, affects subadults and adults **Certainty:** 2		Tashjian et al. 2006
		Point and non-point sources	Widespread, year-round, affects all lifestages **Certainty:** 1		Linville 2002, Greenfield et al. 2005, Doroshov 2006

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Table C-8. Stressors, Stressor Effects, and Impact Mechanisms for White Sturgeon (continued)

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Moderately Important Stressors					
Reduced rearing habitat	Reduced growth rates, increased predation	Reclaiming wetlands and islands reduced in- and off-channel rearing habitat	Widespread in Delta, year-round, juveniles and sub-adults **Certainty:** 1		
		Channelized riprap levees reduce in- and off-channel intertidal and shallow subtidal rearing habitat, including seasonal inundation of floodplain habitat	Widespread in Delta, year-round, juveniles and sub-adults **Certainty:** 1		
Increased water temperature	Increased heat-related physiological stress (heat-shock proteins), increased susceptibility to disease, mortality	Reduced flows from upstream reservoirs increase hydrologic resident time, allowing water to warm, reduced riparian vegetation and shading	Occurs in Feather River, primarily in spring/summer, primarily influences eggs and juveniles **Certainty:** 3		Cech et al. 1984, SWRI 2003
Unnatural mortality	Mortality	Predation by non-natives	Occurs upstream in and near spawning habitat during and shortly after spawning season, affects larvae and juveniles **Certainty:** 2	Predation risk increases with lower turbidity	Gadomski & Parsley 2005a
		Dredging directly entrains sturgeon	Occurs in specific main channels, year-round, rearing juveniles and sub-adults **Certainty:** 1		
Reduced turbidity	Increased risk of predation	Upstream water management & channelization reduces sediment input	Only been shown for white sturgeon but likely translates to green sturgeon, occurs upstream in and near spawning habitat during and shortly after spawning season, affects larvae **Certainty:** 2		Jassby et al. 2002, Gadomski & Parsley 2005b

Other stressors:

- Unnatural mortality
    - Monitoring mortality
    - Stranding
- Entrainment (SWP, CVP, and others)
- Salinity control
- Reduced food

Individuals participating in the BDCP technical working sessions for sturgeon include:

Diane Windham and Jeff Stuart (NMFS); Scott Cantrell, Tom Schroyer, and Mike Donnellan (DFG); Zoltan Matica and Alicia Seesholtz (DWR); Rick Sitts (Metropolitan); Campbell Ingram (TNC); Josh Israel (UC Davis); Chuck Hanson (Hanson Environmental); Pete Rawlings and Rick Wilder (SAIC).

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Table C-9. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento Splittail

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors					
Reduced juvenile/ adult rearing habitat	Reduced growth, increased competition	Reclaiming wetlands and islands reduced shallow, low velocity, brackish habitat (splittail rearing habitat)	Widespread throughout the rearing range of splittail, year-round, affects juveniles and rearing adults **Certainty:** 3		Moyle et al. 2004, Feyrer et al. 2005
Reduced spawning/ larval rearing habitat	Reduced reproductive success, mortality from stranding, reduced growth rate and/or survival of offspring	Upstream reservoir operations reduce the frequency and magnitude of high flows, reducing extent and duration of floodplain inundation (splittail spawning/larval rearing habitat)	Limited to floodplains and other flow-dependant habitat, during late winter & spring, occurs primarily in low flow years, affects spawning adults and larvae **Certainty:** 4		Sommer et al. 1997, 2004, Meng & Matern 2001, Moyle et al. 2004, Feyrer et al. 2005
		Riprapped levees reduce low velocity, shallow water habitat used for spawning and early larval rearing habitat	Moderate geographic scope, most significant in dry years during spawning and early rearing season (late winter/spring), affects spawning adults, larvae, juvenile, and subadult rearing year-round **Certainty:** 3	Importance increases during dry years when floodplains are inaccessible (see previous impact mechanism)	Moyle 2002, Feyrer et al. 2005
Reduced food	Starvation, reduced reproduction, higher susceptibility to disease	Non-native species (e.g., *Corbula*) reduce food available to splittail by eating/filtering out organics, phytoplankton, and zooplankton.	Can affect larvae, juveniles, and adults in all locations throughout the year, but mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods. **Certainty:** 4	Importance increases during dry years when floodplains are inaccessible	Kimmerer & Orsi 1996, Jassby et al. 2002, Kimmerer 2002a, Moyle et al. 2004

1 **Table C-9. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento Splittail (continued)**

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Upstream reservoir operations dampen high flows and do not allow nutrients and production on floodplains to be mobilized and transported downstream	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, mainly in drier years, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high. **Certainty:** 3		Jassby et al. 2002, Feyrer et al. 2006, Pelagic Fish Action Plan 2007
		Nutrients and phytoplankton and zooplankton production are exported by SWP, CVP, and in-Delta diversions with water	Widespread stressor throughout geographic range, can affect larvae, juveniles, and adults throughout the year, rearing juveniles and adults in western Delta and Suisun Bay when flows are low and exports are high. **Certainty:** 3	Importance increases during dry years when floodplains are inaccessible	Jassby et al. 2002, Pelagic Fish Action Plan 2007
		Hydrologic residence time in the Delta, which affects production, is reduced by SWP and CVP exports from the south Delta, which moves water more quickly through the Delta channels	Can affect larvae, juveniles, and adults throughout the year, mostly rearing juveniles and adults in western Delta and Suisun Bay during low production periods. **Certainty:** 3	Importance increases during dry years when floodplains are inaccessible	Jassby et al. 2002, Kimmerer 2002a,b, Pelagic Fish Action Plan 2007
Exposure to toxics	Sublethal and lethal effects, increased susceptibility to disease	Toxics enter the system from a variety of point and non-point sources including agricultural and urban run-off	Widespread throughout geographic range, can be episodic and chronic, can affect all life stages **Certainty:** 3		Teh et al. 2002, 2004a,b, 2005; Greenfield et al. in review

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1 **Table C-9. Stressors, Stressor Effects, and Impact Mechanisms for Sacramento Splittail (continued)**

Stressor	Effect on Species	Important Impact Mechanism	Comments	Relationships to Other Stressors	Citations
Highly Important Stressors (cont.)					
		Corbula as a food source contribute to bioaccumulations of toxics like selenium in splittail tissue via consumption	Specific to locations with *Corbula* presence (western Delta, Suisun Bay), year-round, affects subadults and adults **Certainty:** 2		Stewart 2000
Moderately Important Stressors					
Unnatural predation	Mortality	Non-native submerged aquatic vegetation provides suitable habitat for non-native predators that prey on splittail	Widespread throughout geographic range, impacts larvae, juveniles, smaller adults, year-round **Certainty:** 3		Simenstad 1999, Moyle 2002, Toft et al. 2003, Nobriga et al. 2005, Brown & Michniuk 2006
SWP/CVP entrainment	Mortality, injury, displacement if salvaged successfully	Reverse flows in Old and Middle rivers entrain or guide splittail, eventually moving them into the SWP and CVP export facilities	Adults affected during spawning season (December-March), larvae and juveniles affected during first few months of life (usually Feb-May **Certainty:** 3	Entrainment generally highest in wet years when population most robust and lowest in dry years	Sommer et al. 1997, Danley et al. 2002, Moyle et al. 2004
Harvest	Mortality	Legal fishery	Unknown geographic range, affects smaller adults (15-25 cm TL), from November through May, numbers of splittail harvested are unknown **Certainty:** 2		Moyle et al. 2004
		Illegal fishery (suspected)	Likely similar spatial and temporal range to legal fishery **Certainty:** 1		

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Other stressors:

- Non-natural mortality
  - Non-CVP/SWP entrainment
  - Propeller entrainment by cargo vessel
  - Stranding
- Salinity control

Individuals participating in the BDCP technical working sessions for Sacramento splittail:

Chuck Hanson (Hanson Environmental); Diane Windham (NMFS); Scott Cantrell and Dan Kratville (DFG); Victoria Poage (USFWS); Bill Harrell and Stephani Spaar (DWR); Rick Sitts (Metropolitan); Campbell Ingram (TNC); Bruce Herbold (EPA); BJ Miller; and Pete Rawlings and Rick Wilder (SAIC).

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